Staging Glaucoma Patient: Why and How?

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Abstract: Staging glaucomatous damage into appropriatecategories enhances management of the disease. Automated static perimetry is the benchmark for testing visual function in glaucoma. Numerous examples of standard automated perimetry staging systems have been proposed but difficulties such as lack of accuracy, absence of information related to location and depth of the defect(s) and need of time-consuming analysis of every visual field test result may reduce their day-to-day clinical usefulness.A new visual field staging system is proposed: the University of São Paulo Glaucoma Visual Field Staging System (USP-GVFSS). In this system, qualitative and quantitative characteristics of the visual field defect are described. The method is intuitive, comprehensible and describes severity, extension and hemi field involvement.

WHY STAGE GLAUCOMA PATIENT?

Staging glaucomatous damage into broad categories of damage such as, mild, moderate, and advanced enhances management. It promotes careful assessment and documentation of clinical damage, thereby facilitating monitoring for stability versus progression and provides a common language for both clinical and research purposes.

HOW TO STAGE GLAUCOMATOUS DAMAGE?

Glaucomatous damage can be quantified using either structural or functional loss criteria, or a combination of both. Patients with glaucoma may present with the disease before damage is detectable with standard achromatic automated perimetry ("pre-perimetric glaucoma") or with clear glaucomatous visual field defect(s). In pre-perimetric glaucoma, clinicians may detect structural changes. However, manual systems based on clinical examination are subjective, relatively poorly reproducible, and require specific clinical experience.

Automated computerized devices analyze and quantify the optic nerve and RNFL thickness objectively with good reproducibility. These include scanning laser ophthalmoscopy, scanning laser polarimetry and optical coherence tomography; each may quantify and allow broad staging of structural damage. However these expensive and sophisticated technologies are evolving faster than clinical assessment of their utility.

Perimetric Glaucoma

Automated static perimetry is the benchmark for testing visual function in glaucoma; in the first evaluation it detects and quantifies damage, and in follow-up of a diagnosed patient, it detects stability or progression of loss. Patients with perimetric glaucoma may be staged on their visual field sensitivities as measured by standard automated perimetry (SAP) based on the number and depth of defective points, mean deviation (MD), or most recently, the visual field index. While these parameters are all Humphrey perimeter based, other perimeter manufacturers have software that offers similar information.

An ideal method to classify functional damage in glaucoma should be objective, reproducible, and user-friendly; it should supply useful information on the characteristics of visual field defects (shape, type, location and depth), it should provide a classification which is consistent with structural damage data, widely accepted and used, and able to monitor even relatively small changes in functional loss over time.

Numerous examples of SAP staging systems have been proposed [1-8]. The most common criteria used by published researches to stage glaucoma, is that of Hodapp, Parish and Anderson (H-P-A) [3].

The H-P-A classification system is a clinically useful method that considers two criteria: the overall extent of damage using both MD value and the number of defective points in the Humphrey Statpac-2 pattern deviation probability map of the 24-2, SITA-STANDARD test. In addition the method takes into consideration, the proximity of defect(s) to fixation (Fig. **1**).

Despite its popularity, this classification has some disadvantages: the visual field defect is characterized into four relatively coarse stages (Fig. **2**); accurate and time-consuming analysis of every visual field test result is required, reducing its day-to-day clinical usefulness; there is no information about the location and depth of the defect(s); And finally, this system may suggest a significant deterioration when in fact none has occurred.

In 2006, Mills *et al.* proposed a new system [8], similar to H-P-A with six stages. (Fig. **3**) The method is considered less friendly than H-P-A requiring an analytical and time –

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Minimum criteria for diagnosing acquired glaucomatous damage

A Glaucoma Hemifield Test outside normal limits on at least two fields; OR

A cluster of three or more non-edge points in a location typical for glaucoma, all of which are depressed on the pattern deviation plot at a p<5% level and one of which is depressed at a p<1% level on two consecutive fields; OR

A corrected pattern standard deviation that occurs in less than 5% of normal fields on two consecutive fields

Classification of defects

Early defect:

- MD less than -6 dB
- Less than 25% of the points (18) are depressed below the 5% level and less than 10 points are depressed below the 1% level on the pattern deviation plot
- All point in the central 5 º must have a sensitivity of at least 15 dB

Moderate defect:

- MD less than -12 dB
- Less than 50% of the points (37) are depressed below the 5% level and less than 20 points are depressed below the 1% level on the pattern deviation plot,
- No points in the central 5º can have a sensitivity of 0 dB
- Only one hemifield may have a point with sensitivity of <15 dB within 5º of fixation

Severe defect (any of the following results):

- MD greater than -12 dB
- More than 50% of the points (37) are depressed below the 5% level or more than 20 points are depressed below the 1% level on the pattern deviation plot
- At least one point in the central 5º has a sensitivity of 0 dB
- Points within the central 5º with sensitivity <15 dB in both hemifields

Fig. (1). Hoddap –Parrish –Anderson criteria.

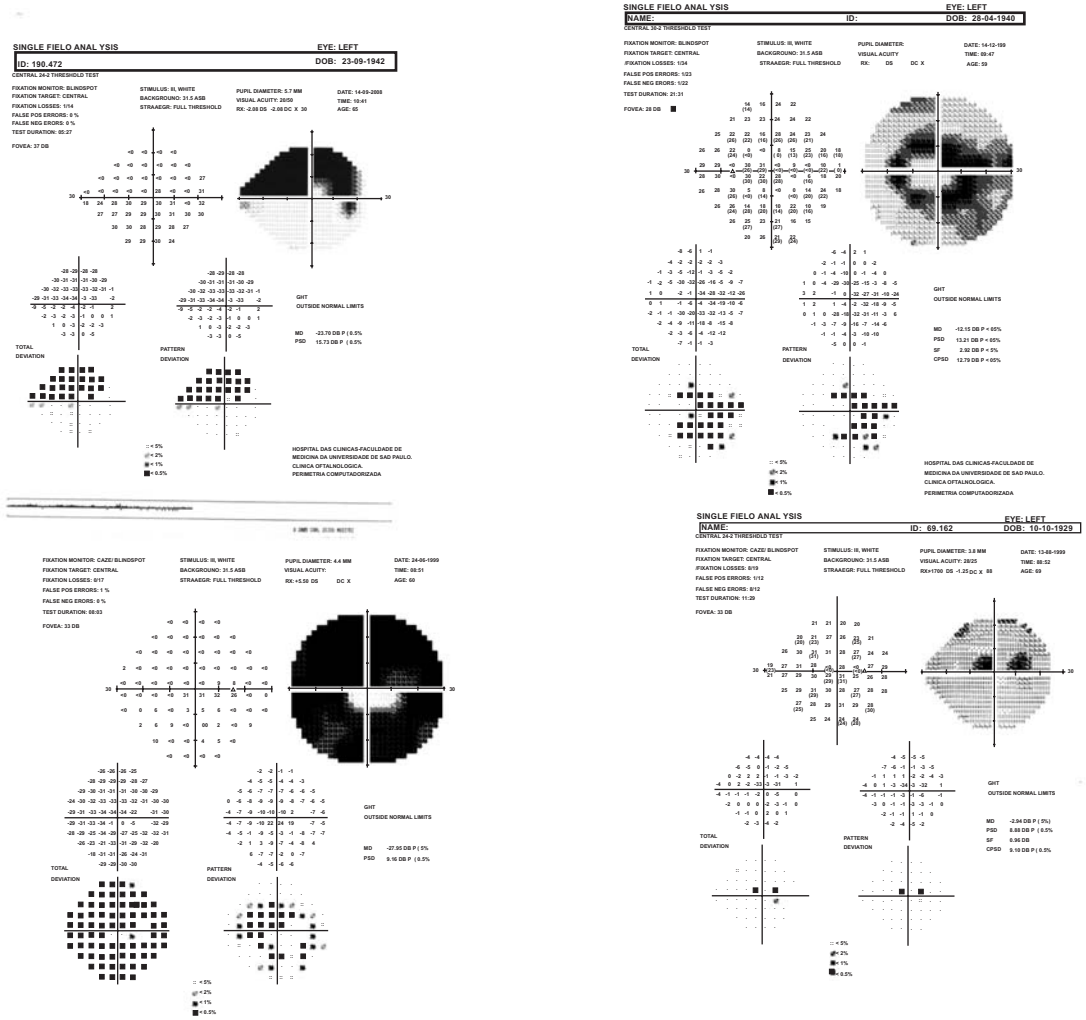

Fig. (2). All visual field defects above are classified as severe by H-P-A classification (at least one point in the central 5 degrees has a sensitivity of 0 dB); however they have different aspects and probably different prognosis.

Stage	Humphrey Mean Deviation (dB)	Probability Plot/Pattern Deviation	dB Plot (Stages 2-4) or CPSD/PSD (Stage 1)	dB Plot (Stages 2-4) or Glaucoma Hemifield Test (GHT) (Stage 1)
Stage 0—Ocular hypertension/earliest glaucoma	> 0.00	—	Does not meet any criteria for Stage 1	—
Stage 1—Early glaucoma	−0.01 to −6.00	> 3 contiguous points at P <.05 and > 1 of the points at P <.01	CPSD/PSD significant (P <.05)	GHT ''outside normal limits"
Stage 2—Moderate glaucoma	−6.01 to −12.00 And ⇒	Points below 5%: 19-36 and points below 1%: 12-18 Or ⇒	> 1 point(s) with sensitivity of < 15 dB and no point with sensitivity of < 0 dB within the central 5° Or ⇒	1 or 2 points with sensitivity <15 dB within 5° of fixation in only 1 hemifield
Stage 3—Advanced glaucoma	−12.01 to −20.00	Points below 5%: 37-55 and points below 1%: 19-36	Only 1 point with sensitivity of <0 dB within the central 5°	At leasl 1 point with sensitivity of < 15 dB within the central 5° in both hemifields
Stage 4—Severe glaucoma	−20.01 or worse	Points below 5%: 56-74 and points below 1%: 37-74	2 to 4 points with sensitivity of <0 dB within the central 5°	At least 2 points with sensitivity of < 15 dB within the central 5° in both hemifields
Stage 5—End-stage	No visual field in worst eye	No visual field attributable to central scotoma Or ⇒	Worst eye visual acuity of 20/200 or worse attributable to glaucoma	Best eye may fall into any of above stages

Fig. (3). Staging system proposed by Mills *et al*. [8].

The AGIS score ranges from 0 to 20, and it is obtained as follows:

A cluster of three or more adjacent depressed test locations among the six test sites in the nasal field constitutes a *nasal defect*. The cluster may cross the horizontal midline.

One or more depressed test locations in the nasal field, either above or below the horizontal midline, in the absence of depression of any of the three test locations on the opposite side of the horizontal midline, constitutes a *nasal step*.

A cluster of three or more depressed sites in a hemifield constitutes a *hemifield defect*. more than one cluster of depressed sites may occur in a hemifield.

Points are awarded to the score as follows:

- For a nasal defect or nasal step, add one to the score, and if four or more of the six nasal test locations are depressed 12 dB or more, add one more to the score.
- In each hemifield with one or more clusters of three or more adjacent depressed test locations (hemifield defects), add one to the score if there are 3 to 5 depressed test sites in the clusters; add two if there are 6 to 12; add three if there are 13 to 20; and add four if there are more than 20.
- If half or more of the adjacent defective locations in a hemifield are depressed 28 dB or more, add five to the score; if half or more are depressed 24 dB or more, add four; if half or more are depressed 20 dB or more, add three; if half or more are depressed 16 dB or more, add two; or if half or more are depressed 12 dB or more, add one. This series of steps may add as much as five to the score for each hemifield containing a deep defect.
- If a hemifield lacks a cluster of three adjacent depressed test sites, but contains at least two adjacent depressed sites of which one is depressed 12 dB or more, add one to the score.

Fig. (4). AGIS score.

consuming assessment of several visual fields; this is even less helpful for day-to-day clinical use.

A more continuous staging system suggested by the Advanced Glaucoma Intervention Study (AGIS) [4], subdivided patients' visual fields into 20 stages, in order to maximize the likelihood of detecting a patient who became worse (Fig. **4**). As it requires a computer program to simplify the calculation of the score, this too is impractical for routine clinical use. The score is obtained from the total deviation plot of Humphrey Visual Field Statpac2. A point is considered defective when a minimal amount of sensitivity depression is reached.

Similar to the AGIS score, in the Collaborative Initial Glaucoma Treatment Study (CIGTS) visual field score, a weight was given based on minimum depth of the defect at any given point in addition to its two most defective neighboring points in the total deviation probability plot of the Humphrey 24-2 threshold test. The score obtained from the 52 points in the field are summed, divided by 10.4 and transformed in a numerical scale.

H-P-A, AGIS and CIGTS visual field staging systems are accurate for localized defects, but they fail to account for subtle diffuse sensitivity depression, which sometimes may be due to early glaucomatous damage.

Other methods such as Brusini's Glaucoma Staging System are based on SAP Indices.[6] Brusini and co-workers used VF indices to obtain information not only related to the severity of the defects, but also about the type of damage. The method is useful to stage the damage severity, to separate the different components of VF loss (generalized, localized and mixed) and to monitor progression over time. The lines that separate the different stages were mathematically determined and the system is comparable with H-P-A and AGIS methods (Fig. **5**).

One downside of this method is that it is strictly based on 2 global indices, and thus can be affected by artifacts and short-term fluctuation. In addition, it does not provide information about location, shape and morphology of visual field defects; therefore very different defects may be classified as similar.

A NEW GLAUCOMA VISUAL FIELD STAGING SYSTEM

The University of São Paulo Glaucoma Visual Field Staging System (USP-GVFSS) proposed by Susanna and Vessani [9] is a new system in which qualitative and quantitative characteristics of the visual field defect are described. The system is intuitive, comprehensible and describes severity, extension and hemi field involvement.

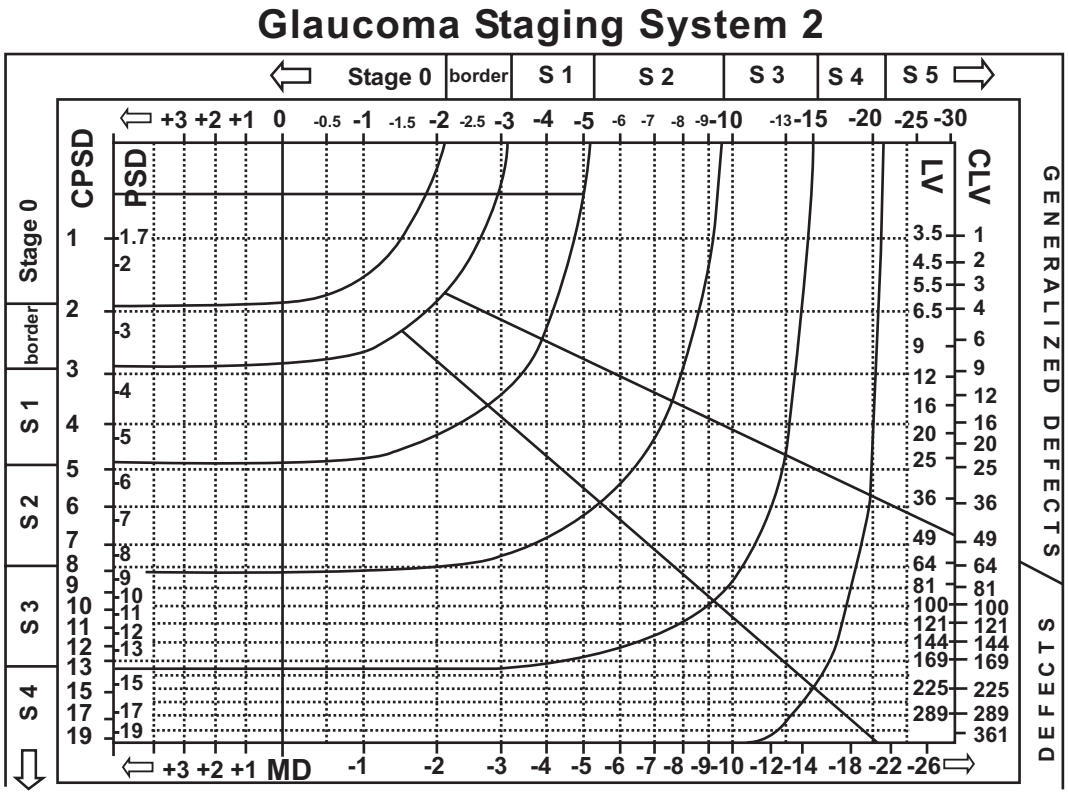

Fig. (5). Brusini *et al.* glaucoma staging system [6].

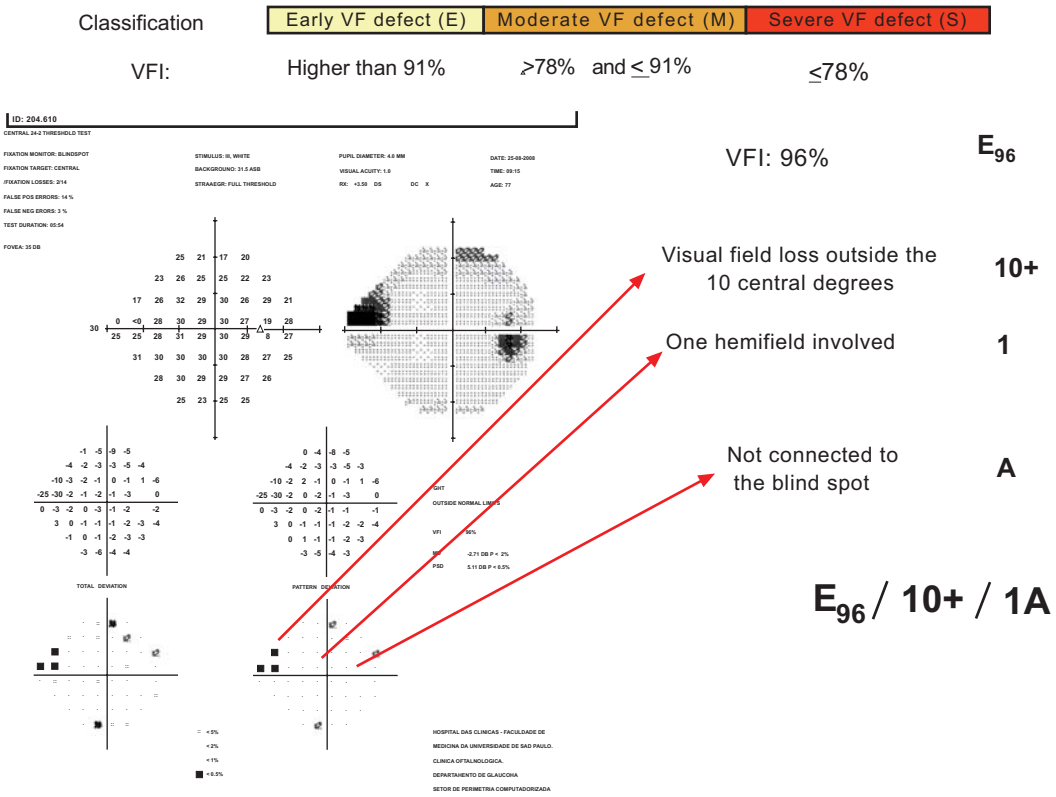

Fig. (6). Description of USP glaucomatous visual field staging system.

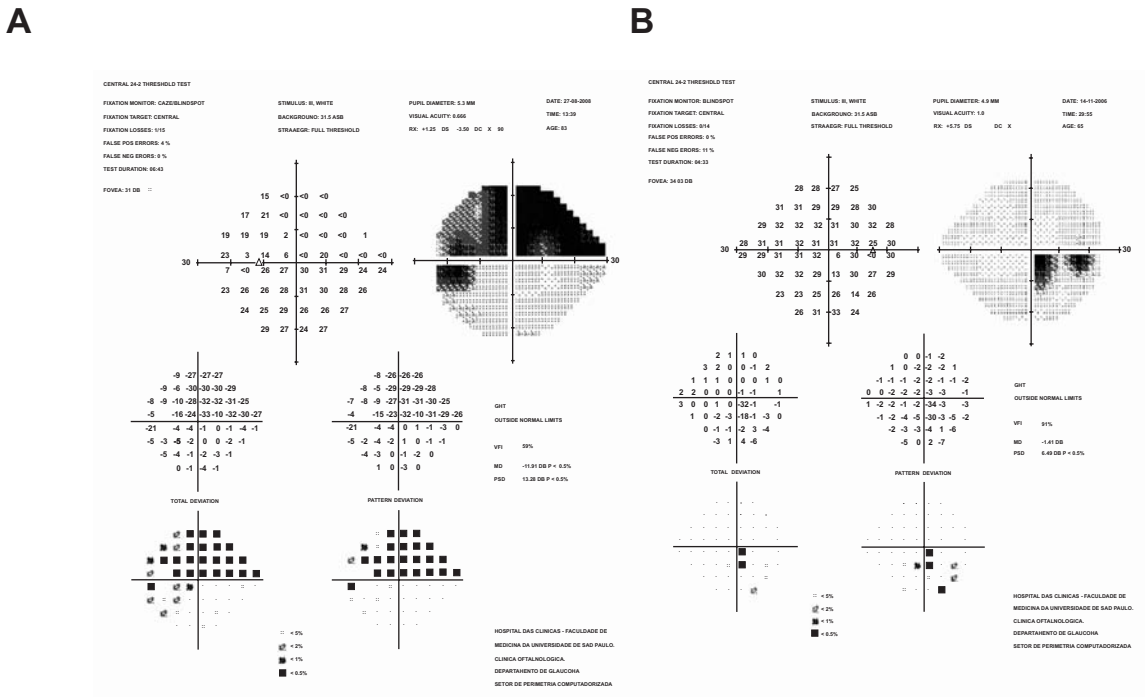

Fig. (7). (**A**) Extensive visual field defect involving superior hemifield (**B**) Paracentral visual field defect. Both defects are classified as severe by Hoddap Parish and Anderson criteria (any point within central 5°with sensitivity less than or equal to 0 dB). Using USP System visual field A would be described as S59/ 5/2B and visual field B as E91/ 5/ 1A, providing clear differentiation between them.

The definition of visual field defect(s) is the same as proposed by the H-P-A system which includes the glaucoma hemifield test outside normal limits or a cluster of three or more non-edge points in a typical location of glaucoma, all depressed on the pattern deviation plot at a p<5% level and one depressed at a p<1% level or a CPSD that occurs in less than 5% of normal visual fields.

The new system proposed includes the Visual Field Index (VFI), a new parameter recently introduced in the Humphrey Visual Field (Carl Zeiss Meditec Inc, Dublin, CA) [10].

The advantages of the VFI include: the replacement of MD (dB) value with % for a full visual field, reduction of cataract effects, comprehensible scale ranging from 100% to 0% (normal function to perimetric blindness), and a weighting procedure applied to reflect ganglion cell loss (central *vs*. peripheral VF loss based on the cortical magnification factor). The Pattern Deviation probability map is used to identify normal and abnormal points. Points <0 dB are considered to have 0% sensitivity. Normal points have100% sensitivity. The amount of loss is then calculated using total deviation numerical maps. Defect depth is recalculated into %.

In USP GVFSS, VFI cut-off values are established for each stage. Location is considered in 3 categories: VF defect inside the 5 central degrees (5); VF defect inside the 10 central degrees but outside the 5 central degrees (10); VF defect outside the 10 central degrees (10+). One (1) versus both hemifield (2) involvement is included. The relationship to the blind spot is based on points depressed below 0.5% level on the pattern deviation plot and it is characterized as A, if the visual field defect is not connected with the blind spot, or B, if the visual field defect is connected with the blind spot. Fig. (**6**) presents an example of this classification describing the characteristics of one glaucomatous visual field defect.

There are several advantages of the USPGSS over the previous methods.

The USP- GVFSS is easier to apply and to memorize. It includes, in a very compact way, a modern visual field index plus information about location of the defect (closeness to the point of fixation and association with the physiological blind spot). This may have clinical relevance: defects that evolve both hemifields may have different prognosis than defects that are located in only one hemifield (Fig. **7**).

Staging visual fields meaningfully is truly challenging for clinicians and researchers. Fine characterization of the glaucomatous visual field allows for the grouping of patients into subtypes and stages visual field loss. This may be important to establish the rate and the risk of progression of each subtype of glaucomatous visual field loss, which is crucial to optimize treatment.

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